

INDOOR AIR QUALITY ASSESSMENT

**Avon Middle/High School
285 West Main Street
Avon, Massachusetts**



Prepared by:
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Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of the Avon Board of Health and parents, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the Avon Middle/High School, 285 West Main Street, Avon, MA. On September 26, 2003, Cory Holmes, Environmental Analyst for BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program, conducted an assessment of this building. Concerns about indoor air quality related to construction/renovations prompted the request.

The school was previously visited in April 1998 by BEHA's ER/IAQ Program and a report was issued (MDPH, 1998) which described the conditions of the building at that time. The report identified problems and gave recommendations on how to correct those problems. Many of these recommendations are being addressed as part of the current renovation/addition project.

The school was built in 1955 and consists of upper and lower wings. The upper wing houses high school students. The lower wing, which was added in 1970 houses middle school students. Connecting the upper and lower wings is an enclosed corridor. The construction project consists of the building of two additions and renovation of the existing building. One of the additions is being built adjacent to the occupied building. At present, no construction/demolition work is being done in the occupied building with the exception of some punch list items in the media center.

Prior to the BEHA assessment, two private environmental consultants evaluated the building (Gurton, Elkerton and Associates (GE&A) and OccuHealth, Inc. (OccuHealth)). These evaluations occurred on the first and second days of the current school year. Testing by GE&A included; carbon dioxide, carbon monoxide, temperature, relative humidity, particulates, airborne

crystalline silica and total volatile organic compounds (TVOCs) (GE&A, 2003). The GE & A report recommended (1) operating ventilation while rooms are occupied; (2) continued particulates monitoring; and (3) flushing the building with fresh outdoor air (GE&A, 2003). Testing by OccuHealth, Inc. consisted of airborne ultrafine particles (UFPs), airborne mold spores and dust characterization (OHI, 2003). The OHI report recommended (1) closing all doors and windows during the school day to allow univents to filter classroom air; (2) replacing univent filters with one-inch pleated filters; and (3) conducting an air survey after the installation of (new) univents to assure the systems are properly balanced (OHI, 2003)

Methods

BEHA staff conducted air tests for carbon dioxide, carbon monoxide, temperature and relative humidity using the TSI, Q-Trak, IAQ Monitor Model 8551. Screening for TVOCs was conducted using a Thermo Environmental Instruments Inc., Model 580 Series, Photo Ionization Detector (PID). Air tests for UFPs were taken with the TSI, P-Trak TM Ultrafine Particle Counter Model 8525.

Results

The school houses fifth through twelfth grades with a student population of approximately 480 and a staff of approximately 60. Tests were taken during normal operations at the school and results appear in Table 1.

Discussion

Ventilation

It can be seen from the Table 1 that carbon dioxide levels were elevated above 800 parts per million parts of air (ppm) in twelve of fifteen areas surveyed, indicating inadequate air exchange in a number of areas. It should be noted that during the assessment, several univent rooftop fresh air intakes had been removed for intended replacement. In order to provide fresh air to occupied areas, temporary air handling units (AHUs) were being used. However, these units introduce a limited amount of air into the space and do not have the capacity to provide return/exhaust ventilation. A number of univents in perimeter classrooms were deactivated. In order for univents to provide fresh air as designed, these units must remain activated and allowed to operate while rooms are occupied.

The mechanical exhaust ventilation system in classrooms consists of grated, wall-mounted return vents that draw air to rooftop motors. As discussed, in rooms with temporary AHUs, no exhaust ventilation was being provided. Normally occurring environmental pollutants can build up and lead to indoor air complaints without removal by the exhaust ventilation system.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical ventilation system, the systems must be balanced subsequent to installation to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room

(SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please consult [Appendix A](#).

Temperature measurements ranged from 74° F to 77° F, which were within the BEHA comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in the building ranged from 53 to 65 percent, which was above the BEHA recommended comfort range in some areas. The BEHA recommends a

comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity in excess of 70 percent can provide an environment for mold and fungal growth (ASHRAE, 1989).

Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Renovations

The school is under renovation/construction while occupied by students, teachers and school administration employees. It is important to note that the State Department of Education amended their regulations in 1999 to address such concerns for school renovation projects in Massachusetts (MDOE, 1999).

Renovation activities can produce a number of pollutants, such as volatile organic compounds (VOCs) found in paints, mastics and other materials, which are carbon-based chemicals that rapidly evaporate causing eye, nose and respiratory irritation. No increased levels of TVOCs over background levels were measured in occupied areas of the school during the assessment. Other pollutants include dirt, dust, particulates, and combustion products such as CO (from construction vehicles). Particles generated from construction activities can settle on horizontal surfaces in classrooms. Dusts can be irritating to the eyes, nose and respiratory tract.

The US Environmental Protection Agency has established National Ambient Air Quality Standards (NAAQS) for exposure to carbon monoxide in outdoor air. Carbon monoxide levels in outdoor air must be maintained below 9 ppm over a twenty-four hour period in order to meet this standard (US EPA, 2000). While no elevated CO levels were measured during the assessment, CO was detected in a few areas.

The combustion of fossil fuels, welding, steel cutting, concrete/brick boring and other renovation activities can produce particulate matter that is of a small diameter ($<10\text{ }\mu\text{m}$) (UFPs), which can penetrate into the lungs and subsequently cause irritation. For this reason a device that can measure particles of a diameter of $10\text{ }\mu\text{m}$ or less was used to identify pollutant pathways from the renovation site into occupied areas.

The instrument used by BEHA staff to conduct air monitoring for UFPs counts the number of particles that are suspended in a cubic centimeter (cm^3) of air. This type of air monitoring is useful in that it can track and identify the source of airborne pollutants by counting the actual number of airborne particles. The source of particle production can be identified by moving the UFP counter through a building towards the highest measured concentration of airborne particles. Measured levels of particles/ cm^3 of air increase as the UFP counter is moved closer to the source of particle production. While this equipment can ascertain whether unusual sources of ultrafine particles exist in a building or that particles are penetrating through spaces in doors or walls, it cannot be used to quantify whether the NAAQS PM_{10} standard was exceeded. The primary purpose of these tests at the school was *to identify and reduce/prevent pollutant pathways*. Air monitoring for UFPs was conducted in classrooms and hallways and other areas, which may be directly impacted from close proximity to renovation sites. For comparison, measurements in areas away from renovation sites indoors as well as outdoors were taken. No increased levels of UFPs over background levels were measured in occupied areas of the school during the assessment.

As described in the Ventilation section, a number of unit ventilators were not operating in classrooms. The deactivation of these ventilation system components can lead to an increased concentration of normally occurring dust that is generated during occupancy, as well as any construction generated dust that may be present. The operation of ventilation system

components can serve to reduce concentration and accumulation of dust in classrooms for the following reasons:

- Univents introduce fresh air into classrooms. Introduction of fresh air can serve to dilute airborne concentrations of particles.
- Univents are equipped with filters that can strain airborne particles from air. The operation of univents can serve as a constantly operating, stationary “vacuum cleaner” that can assist in removing airborne dust.
- The exhaust ventilation system provides a means to remove stale air and other pollutants from a room. The univent exhaust vents assist in removing normally occurring dust and particles from the building.

For these reasons, operation of the existing ventilation system can aid in the overall reduction of accumulated dust within occupied areas of the building.

A number of construction vehicles and several large piles of dirt/construction debris were noted in the area of the addition between the two buildings, which forms a semi-enclosed courtyard. This activity should be closely monitored to avoid the entrainment of vehicle exhaust and other construction generated pollutants inside the building via open doors, windows or univent fresh air intakes (Picture 1). A number of classrooms adjacent to the construction zone had open windows. The nature of the construction has generated large amounts of dirt and debris piled outside of the building (Pictures 1 & 2). The opening of windows allows for unfiltered air to enter the classroom environment carrying with it airborne dirt, dust and particulates. In many areas, accumulated dirt and dust was observed on horizontal surfaces (Picture 3). Also noted in these areas were items seen piled on flat surfaces such as windowsills, countertops, cabinets and desks, which make it difficult for custodial staff to clean. Dusts can be irritating to the eyes, nose and respiratory tract. Other pathways were observed for construction-

generated pollutants to enter the building. The gymnasium exterior wall adjacent to construction activity had a large hole, from which light could be seen penetrating (Pictures 4 & 5). Also noted in the gymnasium were spaces between and around exterior doors, spaces similar to these were seen around other exterior doors in the building (Pictures 6 & 7).

Conclusions/Recommendations

Air testing results taken during the assessment indicate that no elevated levels of renovation-generated pollutants (e.g., CO, TVOCs, UFPs) were measured inside the occupied areas, however it is important that univents and classroom exhaust vents are activated in occupied classrooms. General exhaust ventilation (where operable) should be reduced to maintain a slightly positive air pressure in classrooms.

The following recommendations should be implemented in order to reduce the migration of renovation-generated pollutants into occupied areas and the potential impact on indoor air quality:

1. Comply with 603 CMR 38.00: School Construction – Massachusetts Department of Education. This regulation states that “[a]pplicants shall implement containment procedures for dusts, gases, fumes, and other pollutants created during renovations/construction as part of any planned construction, addition to, or renovation of a school if the building is occupied by students, teachers or school department staff while such renovation and construction is occurring. Such containment procedures shall be consistent with the most current edition of the IAQ Guidelines for Occupied Buildings Under Construction published by the Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA). All bids received for school construction or renovations shall include the cost of planning and execution of containment of

construction/renovation pollutants consistent with the SMACNA guidelines [608 CMR 38.03(13)] General Requirements: Capital Construction” (MDOE, 1999).

2. Establish communications between all parties involved with building renovations to prevent potential IAQ problems. Develop a forum for occupants to express concerns about renovations as well as a program to resolve IAQ issues.
3. Develop a notification system for building occupants immediately adjacent to construction activities to report construction/renovation related odors and/or dusts problems to the building administrator. Have these concerns relayed to the contractor in a manner to allow for a timely remediation of the problem.
4. When possible, schedule projects which produce large amounts of dusts, odors and emissions during unoccupied periods or periods of low occupancy.
5. Cover dirt/debris piles with tarps or wet down to decrease aerosolization of particulates, when possible.
6. Faculty should be aware of construction activities, which may be conducted in close proximity to their classrooms. In certain cases, classrooms adjacent to construction activities may need to have their HVAC equipment deactivated and windows closed periodically to prevent unfiltered air and vehicle exhaust from entering the building. For this reason, prior notification(s) should be made.
7. Disseminate scheduling itinerary to all affected parties, this can be done in the form of meetings, newsletters or weekly bulletins.
8. Obtain Material Safety Data Sheets (MSDS) for all construction materials used during renovations and keep them in an area that is accessible to all individuals during periods of building operations as required by the Massachusetts Right-To-Know Act (MGL, 1983).

9. Consult MSDS' for any material applied to the effected area during renovation(s) including any sealant, carpet adhesive, tile mastic, flooring and/or roofing materials. Provide proper ventilation and allow sufficient curing time as per the manufacturer's instructions concerning these materials.
10. Use local exhaust ventilation and isolation techniques to control for renovation pollutants. Precautions should be taken to avoid the *re-entrainment* of these materials into the building's HVAC system. The design of each system must be assessed to determine how it may be impacted by renovation activities. Specific HVAC protection requirements pertain to the return, central filtration and supply components of the ventilation system. This may entail shutting down systems (when possible) during periods of heavy construction and demolition, ensuring systems are isolated from contaminated environments, sealing ventilation openings with plastic and utilizing filters with a higher dust spot efficiency where needed (SMACNA, 1995).
11. Seal around exterior doors with weather stripping and door sweeps; repair/seal breach in the gymnasium to eliminate pollutant paths of migration. Inspect these areas regularly to ensure integrity is maintained.
12. If possible, relocate susceptible persons and those with pre-existing medical conditions (e.g., hypersensitivity, asthma) away from areas of renovations.
13. Implement prudent housekeeping and work site practices to minimize exposure to renovation pollutants. Consider increasing manpower or work hours (e.g. before school) to accommodate increase in dirt, dust accumulation due to construction/renovation activities. This may include constructing barriers, sealing off areas, and temporarily relocating furniture and supplies. To control for dusts, a high efficiency particulate air filter (HEPA)

equipped vacuum cleaner in conjunction with wet wiping/mopping of all surfaces is recommended.

14. Close windows adjacent to construction activities to prevent unfiltered air from entering the building.
15. Consider mounting a filter medium on the exterior of univent air intakes to minimize entrainment of construction generated dust and debris. Change HVAC filters more regularly in areas impacted by renovation activities. Examine the feasibility of acquiring more efficient filters for these units.

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Picture 1



Construction Vehicle /Excavation Outside Classroom

Picture 2



Site of New Addition/Excavation in Semi Enclosed Courtyard

Picture 3



Accumulated Dust on Flat Surface

Picture 4



Breach in Gymnasium Wall

Picture 5



Breach in Gymnasium Wall Exterior View

Picture 6



Spaces around Gymnasium Doors Adjacent to Construction Site

Picture 7



Spaces around Connecting Corridor Doors Adjacent to Construction Site

TABLE 1

Indoor Air Test Results – Avon Middle/Senior High School, Avon, MA – September 26, 2003

Location	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	Ultrafine Particulates **1000p/cc ³	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Background	410	0-1	0.0	15-24	68	61					Overcast, NE wind 10-15 mph, light construction traffic, moderate street traffic
Media Center	942	0	0.0	6.4	72	61	1	N	N	Y	New carpet odors, exhaust vents being installed/activated
Gym	794	0	0.0	12.5	77	58	0	N	Y	Y	Temporary storage, large breach in wall, spaces around exterior doors, dirt, dust & debris on floor/flat surfaces, adjacent to construction site
Hallway Woodshop			0.0	8.4							Woodshop sanding with hallway door open, odors in hallway
Music Room	1047	0-1	0.0	8.3	77	56	9	N	Y	Y	Hallway door open
211	1113	0-1	0.0	9.7	77	57	5	Y	Y	Y	
158	701	0	0.0	7.9	77	53	2	N	N	N	

* ppm = parts per million parts of air

1000p/cc³ = particles per cubic centimeter parts of airComfort Guidelines**

Carbon Dioxide - < 600 ppm = preferred
 600 - 800 ppm = acceptable
 > 800 ppm = indicative of ventilation problems

Temperature - 70 - 78 °F

Relative Humidity - 40 - 60%

Table 1-1

TABLE 1

Indoor Air Test Results – Avon Middle/Senior High School, Avon, MA – September 26, 2003

Location	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	Ultrafine Particulates **1000p/cc ³	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
212	596	0	0.0	10.9	75	53	28	Y	Y	Y	Window open
202 B Hallway	1067	0	0.0								Interior doors open, exterior doors spaces
202 B	136	0	0.0	10.5	75	65	7	Y	Y	Y	Univent/exhaust off, window open
201	1216	0	0.0	5.1	75	61	25	Y	Y	Y	Window open
Teachers' Lounge	904	0	0.0	7.2	76	58	2	N	N	N	
112	840	0	0.0	6.9	74	65	20	Y	Y	Y	Window open
107	966	0	0.0	5.2	74	65	18	Y	Y	Y	Window open
104	1033	0	0.0	6.0	71	64	21	Y	Y	Y	Window open
103 A	1220	0	0.0	4.1	77	64	22	Y	Y	Y	Exterior door open
102 A	1073	0	0.0	4.8	77	61	22	Y	Y	Y	Corner classroom
Connecting Corridor											Spaces between/ beneath exit doors- adjacent to construction/excavation site

* ppm = parts per million parts of air

1000p/cc³ = particles per cubic centimeter parts of airComfort Guidelines**

Carbon Dioxide - < 600 ppm = preferred
 600 - 800 ppm = acceptable
 > 800 ppm = indicative of ventilation problems

Temperature - 70 - 78 °F

Relative Humidity - 40 - 60%

Table 1-2